(19) FRENCH REPUBLIC

NATIONAL INSTITUTE
OF INDUSTRIAL PROPERTY

PARIS

(11) **Publication No.:** **2 759 471**
(To be used only in ordering copies)

(21) **National Registration No.:** **98 01671**

(51) Int. Cl.^{6}: **G 06 F 3/06**, G 11 B 11/03

(12) # PATENT APPLICATION A1

(22) **Filing date:** February 12, 1998

(30) **Priority:** February 12, 1997 JP 02779397

(43) **Date application laid open to the public:** August 14, 1998 Bulletin 98/33.

(56) **List of documents cited in the preliminary search report:** *The preliminary search report has not been prepared as of the publication date of the application.*

(60) **References to other related national documents:**

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(54) DIGITAL DISK REPRODUCTION SYSTEM, APPARATUS AND METHOD

(57) The invention concerns a reproduction system.

It relates to a system comprising a host apparatus (2) and an apparatus (1) to effect reproduction from a predetermined recording medium, which are in mutual communication. The reproduction apparatus (1) comprises a device for reproducing data from the medium and a device for reproducing defect management data in accordance with a command from the host apparatus (2) and a read request and read position data from the host apparatus (2), and the host apparatus (2) comprises a defect management device and a reproduction request device designed to command the reproduction apparatus (1) to read the defect management data.

Application to digital video disks (DVDs).

The present invention concerns a reproduction system comprising, for example, a reproduction apparatus (disc drive apparatus) capable of performing a reproduction operation on a disc-shaped recording medium, and a host apparatus (for example, a computer having a disc drive circuit function) connected to the reproduction apparatus to command the execution of reproduction. The present invention also [concerns] a corresponding reproduction method.

Compact discs (CDs) constituting optical-disc recording media are now widely used, and these CD-system discs are employed in various fields. In particular, compact-disc read-only memories (CD-ROMs), writable [sic] compact discs (CD-Rs), etc., are often used for computers.

In addition, discs known as "digital versatile discs" or "digital video discs" (DVDs) suitable for multimedia use have been developed. It has been proposed to adapt DVDs to various types of data, such as video data, audio data and computer data. Although DVDs are the same size (12 cm in diameter) as compact discs or CDs, they have a much larger storage capacity, obtained by the formation of smaller-pitch recording tracks and by data compression techniques.

DVDs include types such as DVD read-only memories (DVD-ROMs), which are used solely for reproduction, rewritable DVD digital versatile discs (DVD-Rs), which can be rewritten once, and DVD direct-access [sic] memories (DVD-RAMs).

It has been proposed to use replacement processing for defect management with DVD-RAM media, since they have a random-access function.

In other words, when a defective region is found by checking a disc while the disc is being formatted or used, the defective region is assigned to another region. Data concerning the defective region and data concerning the region of assignment are then recorded as defect management data (defect map) in a special area formed on the disc.

When an actual reproduction request is generated, a logical address relating to the request is transformed into a physical address that corresponds to a real address on the disc. If

a portion of the logical address corresponds to the defective region being managed by means of the defect management data, an address at which an actual read operation is executed must be generated by transforming the address of only the defective portion, so that it is replaced by the address of the replacement region.

Inversely, DVD-ROM media do not require defect management that includes such a replacement operation.

There now follows a description of the structure of a DVD disc drive device (DVD reproduction apparatus). When the reproduction apparatus is to be used solely for DVD-ROMs, it does not have to have a defect management function. Thus, when a reproduction request is transmitted by the host computer, the only necessary operation is the transformation into a physical address of a logical address in the form of reproduction position data transmitted by the host computer connected to the reproduction apparatus. In general, the logical addresses are such that the beginning of the user area on a disc is used as the start (address zero). The physical addresses are addresses numbered from the start, including the control-data area preceding the user area. Thus, the transformation of a logical address into a physical address merely requires the addition of an offset that adds to the logical address an address value preceding the user area, making it unnecessary to use relatively large microinstructions to execute the logical-address-to-physical-address transformation function. Thus, a reproduction apparatus intended solely for DVD-ROMs is very inexpensive to produce.

A reproduction apparatus intended solely for DVD-RAMs, however, must have the structure of the disc reproduction apparatus 91 shown in Fig. 1.

Figure 1 uses reproduction function blocks to represent the disc reproduction apparatus 91 and the host computer 92. The host computer 92 is provided with software constituting an apparatus drive circuit 96 functioning by means of an operating system 97 to adapt it to the disc reproduction apparatus 91. The drive circuit 96 includes a file system function 96a designed to read and save file management data from a disc loaded into apparatus 91, [and] a drive circuit function 96b that executes the reading of data from a file requested by the operating system OS from file data managed by file system function 96a.

The disc reproduction apparatus 91 includes a disc drive unit 93 (designed to permit the

actual reproduction of data from the disc) composed, for example, of an optical head, a servomechanism and a decoding circuit, and a controller designed to cause the disc drive unit 93 to execute an operation necessary for reproduction in accordance with the [sic] request from the host computer 92.

The disc reproduction apparatus 91 and the host computer 92 are interconnected by communication via a small computer systems interface (SCSI) or an AT [advanced technology] attachment packet interface (ATAPI).

In the aforesaid reproduction system, comprising the host computer 92 and the disc reproduction apparatus 91, when a read request transmitted to [sic] a certain data file is generated by the operating system 97, the disc drive circuit 96 transmits to apparatus 91 a position-data read command for executing a read operation. The position data include, for example, the start address of an area to be read and a data-file length (data length). The start address to be transmitted is a logical address that depends on the data-file management of the disc by the host computer 92.

The controller 94 of apparatus 91 receives the read command and the address and the data length (in the form of position data) from the computer 92 and causes the disc-drive unit 93 to execute a read operation in accordance with the transmitted-data command[1]. In the disc drive unit 93, an actual access operation is executed on the basis of a physical address. Thus, the transmitted data-length and logical-address data must be transformed into length and physical-address data.

In the case of a DVD-ROM medium, a physical address can be obtained in the form of the sum by simple addition of an offset value and a logical address. In this operation, an offset adding function 94a is executed in controller 94.

Inversely, a DVD-RAM medium must respond to the defect management condition. Thus, the controller 94 is provided with a defect table function 94b designed to contain a table generated from the defect management data read from the disc and the included replacement data, that is, a defect table generated to facilitate address transformation based on

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[1]TRANSLATOR'S NOTE: Literally, the command (or "control") of the transmitted data. The French in this document is inconsistent and oddly phrased, and seems to be a poor translation of another text.

the replacement data, and an address transformation function 94c that performs the address transformation based on the defect table so generated.

Through the use of these functions 94a and 94b, address transformation can be performed, when necessary, based on the replacement information attendant on a defect, such as a scratch, and a physical address at which the data included in the data file to be read are actually recorded and the data length can be generated. The controller 94 commands the disc drive unit 93 to execute a reproduction operation at the location represented by the physical address and the data length.

This operation permits the reproduction of the data file requested by the disc-drive unit 93, and the reproduced data file is transmitted to the host computer 92.

As described hereinabove, the reproduction apparatus designed for DVD-RAMs must have the defect table function 94b and the address transformation function 94c for executing defect management. For the reproduction apparatus designed for DVD-RAMs to be able to contain the defect management information, if the maximum number of defects is *d* and the address data are *a* bytes[2] (for example, approximately 7 to 8 bytes) in length, a storage area having *d* x *a* bytes is necessary. If the maximum number of defects is 2,000, there must be a 14- to 16-kilobyte storage area.

The reproduction apparatus designed solely for DVD-ROMs, in which a storage area is superfluous, must have a storage capacity of a few kilobytes, and consequently the RAM memory normally built into the CPU of the controller 94 is normally used. However, for the reproduction apparatus designed solely for DVD-ROMs to be adaptable to DVD-RAMs, an additional 14- to 16-kilobyte memory is necessary.

Moreover, relatively large microinstructions are needed in order to use the stored defect management data to generate a defect table and to use the defect table for actual address transformation. The microinstructions are generally a few kilobytes in size.

Moreover, the use of storage capacity for the microinstructions increases the size and cost of the disc reproduction apparatus and constitutes a disadvantage.

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[2]TRANSLATOR'S NOTE: French "octet," specifically an eight-bit byte. (This applies to "byte" and "kilobyte" throughout the translation.)

Thus, it is an object of the present invention to provide a reproduction system and method for realizing a reproduction apparatus designed not only for DVD-ROMs, but also for DVD-RAMs, without increasing the size and cost of said reproduction apparatus.

To this end, according to one aspect of the present invention, the aforesaid object is achieved by the realization of a reproduction system comprising a host apparatus and a reproduction apparatus designed to execute a reproduction operation with respect to a predetermined recording medium, the two apparatuses being connected so that they mutually communicate, such that the reproduction apparatus comprises a reproduction device designed to read data from the predetermined recording medium, and a reproduction control device designed to cause the reproduction device to read defect management data recorded on the recording medium in accordance with a command from the host apparatus before transmission of the reproduced defect management data to the host apparatus, and to cause the reproduction device to execute a reproduction operation in accordance with a read request and read position data[3] from the host apparatus before transmission of the reproduced data to the host apparatus, and the host apparatus comprises a defect management device designed to contain the defect management data transmitted by the reproduction apparatus, and a reproduction request device designed to command the reproduction apparatus to read the defect management data present on the predetermined recording medium loaded into the reproduction apparatus, and to transform the generated logical read-position data into read-position data adapted to the defect management status of the predetermined recording medium by reference to defect management data stored in the defect management device before transmission of the transformed read-position data with a read request when the host apparatus causes the reproduction apparatus to execute the reading of the data.

The reproduction control device preferably determines whether or not the defect management data are recorded on the predetermined recording medium, and on determining that the defect management data are recorded, the reproduction control device transmits the

[3]TRANSLATOR'S NOTE: Actually, based on the syntax of the French, a "read and read-position-data request." This is incorrect; as the description of the figures makes clear, the host computer transmits a read request accompanied by read position data; it does not request read position data from the reproduction apparatus. The error occurs in the French abstract, in the claims, and in this part of the description. (We have corrected it in all cases.)

defect management data to the host apparatus in accordance with a command from the reproduction request device.

The reproduction control device can determine whether the predetermined recording medium is of a type that is rewritable or is used solely for reading, and on determining that the predetermined recording medium is of a rewritable type, the reproduction control device can transmit the defect management data to the host apparatus following a command from the reproduction request device.

In another aspect of the invention, the aforesaid object is achieved by the realization of a reproduction apparatus designed to execute a reproduction operation from a predetermined recording medium, said reproduction apparatus being connected to a host apparatus so that the apparatuses communicate, the reproduction apparatus comprising a reproduction device designed to execute an operation of reading data from the predetermined recording medium, and a reproduction control device designed to cause the reproduction device to read defect management data present on the predetermined recording medium following a command from the host apparatus before transmission of the reproduced defect management data to the host apparatus, and to cause the reproduction device to execute a reproduction operation in accordance with a read request and read position data from the host apparatus before transmission of the reproduced data to the host apparatus.

The reproduction control device preferably determines whether or not defect management data are recorded on the predetermined recording medium, and on determining that defect management data are recorded, the reproduction control device transmits the defect management data to the host apparatus in accordance with the read request from the reproduction control device.

The reproduction control device can determine whether the predetermined recording medium is of a rewritable type or is used only for reproduction, and on determining that the predetermined recording medium is of a rewritable type, the reproduction control device can transmit the defect management data to the host apparatus in accordance with the read request from the reproduction control device.

In another aspect of the invention, the aforesaid object is achieved by the provision of a reproduction method used in a reproduction system comprising a host apparatus and a

reproduction apparatus, the two being connected so as to communicate mutually in order to execute a data reproduction operation from a predetermined recording medium, the two apparatuses being connected so that they communicate with each other [redundancy sic], the method comprising the following steps: transmitting defect management data read from the predetermined recording medium loaded into the reproduction apparatus to the host apparatus, transforming the generated logical read-position data, as a read position, [into] read-position data adapted to the defect management status of the predetermined recording medium, based on the defect management data transmitted to the host apparatus, and requesting the reproduction apparatus to reproduce the data from the predetermined recording medium loaded into the reproduction apparatus.

The method preferably includes storing the read-position data obtained by transformation of the generated logical read-position data as the read location in accordance with the defect management status of the predetermined recording medium, before the step of requesting the reproduction of data by the reproduction apparatus.

As described hereinabove, in accordance with the invention, the defect management data are read from a recording medium so that defect management of the recording medium can be performed by a host apparatus, and the host apparatus has a necessary address transformation function. When a data reproduction request is generated by the host apparatus and is transmitted to a reproduction apparatus, the host apparatus transmits to the reproduction apparatus physical read-position data obtained after address transformation based on the defect management condition.

Thus, defect management microinstructions of relatively large size do not have to be loaded into the reproduction apparatus, and the reproduction apparatus is therefore also adapted to a RAM recording medium through the use of circuits of the same size and cost as those of the apparatus necessary for a ROM recording medium.

Other characteristics and advantages of the invention will be better understood upon a reading of the following description of exemplary embodiments, made with reference to the appended drawings, wherein:

Fig. 1 is a block diagram depicting a conventional reproduction system;

Fig. 2 is a table depicting the structure of a disc;

Fig. 3 is a table depicting the structure of a disc management area;

Figs. 4A and 4B are diagrams illustrating the disc defect management method;

Fig. 5 is a block diagram depicting the hardware structure of the reproduction system in an exemplary embodiment of the present invention;

Fig. 6 is a block diagram depicting a reproduction system in an exemplary embodiment of the present invention;

Fig. 7 is a flow chart depicting an initial operation executed by a reproduction system in an exemplary embodiment of the invention;

Fig. 8 is a flow chart illustrating a reproduction operation executed by a reproduction system in an exemplary implementation of the invention;

Fig. 9 is a chart illustrating an address transformation operation executed by a reproduction system in an exemplary embodiment of the invention; and

Fig. 10 is a similar chart illustrating an address transformation operation executed by a reproduction system in an exemplary embodiment of the present invention.

A disc reproduction system designed for DVD-ROM and DVD-RAMs, in an embodiment of the present invention, will be described in the following order:

(1) defect management method,

(2) hardware structure of the reproduction system,

(3) functional blocks of the reproduction system,

(4) initial process, and

(5) reproduction operation.

(1) Defect Management Method

An example of a defect management method (illustrated in Figs. 2, 3 and 4) proposed for a DVD-RAM is described below.

Figure 2 shows the schematic structure of a radial area [sic] of a DVD-RAM.

The innermost portion of the DVD-RAM is used as the lead-in region and the outermost portion as the lead-out region. The sections between the lead-in region and the lead-out region are used as the user area. The user area is a region in which a data file is actually recorded or read.

Formed in the innermost, lead-in region are a control area CNT, in which various types of disc management data are recorded, and defect management areas DMA1 and DMA2.

In addition, formed in the outermost, lead-out region are defect management areas DMA3 and DMA4 and a control area CNT in which various types of disc management data are recorded.

The defect management areas DMA2 to DMA4 are used essentially to manage the addresses of defective sections and the addresses of any replacement sectors formed when the defective sections are present in the user area.

To enhance management security, identical contents are recorded in the four defect management areas DMA1 to DMA4.

The user area in which the data file is actually recorded or read is radially separated by a multiple-region domain technique, i.e., *n* domains from a domain zero to a domain (n), as indicated in Fig. 2.

Each domain has a data area and a corresponding replacement area. Thus, when the user area is separated into *n* domains, *n* data areas and *n* replacement areas are formed. When the data area includes a defective portion that is not being used for recording or reproduction because of a scratch, the replacement area forms a portion in place of the defective portion.

The addresses representing positions on the disc are of two types: physical addresses (or physical block addresses, PBAs) and logical addresses (or logical block addresses, LBAs). The physical addresses are generated by sequentially numbering the blocks between the beginning of the lead-in region and the end of the lead-out region. The physical addresses are termed "absolute addresses" of the disc. One block is, for example, a 32-kilobyte (16-sector) data unit that constitutes one ECC [error checking and correction] unit. The tracks on the disc, proceeding from the inner to the outer track, are composed of the sequential blocks.

The logical addresses are assigned to the user area being used as a surface for recording or ordinary reproduction. The start block in the user area corresponds to the logical address zero. In other words, adding to a logical address the address of the lead-in region as an offset yields a physical address that is the sum of the two.

On the DVD, the start address of the user area is set at the physical address 30000h, for example. Hence, the physical address PBA "30000h" equals the logical address LBA "0h".

The logical addresses are not always placed at physically fixed positions on the disc, but are used essentially for the recording of data files. Consequently, when a physical recording position is shifted one block back as a result of defect management or when the block of a given replacement area is used, this change is not reflected in the logical address itself.

Each defect management area DMA1, DMA2, DMA3 or DMA4 formed for defect management contains as defect management data a disc definition structure (DDS), a primary defect list PDL and a secondary defect list SDL, as shown in Fig. 3(a). The DDS is used to manage a position at which the defect management data are recorded. The addresses of the PDL and the SDL, a replacement area, etc., are recorded in the DDS. Thus, when reproduction from the disc is being performed, initially reading the DDS structure gives access to real data for defect management.

As Fig. 3(b) shows, the recorded defect addresses dfaP1, dfaP2, dfaP3, etc. obtained when defective blocks are found are recorded in the PDL, and the number of blocks found at the defect addresses is recorded at the beginning of the PDL as its entry-point number.

A form of defect management by means of the PDL is the so-called "slipping" form, which is generated, for example, when the disc is formatted.

For defect management, initially the entire recording surface of the disc is checked for defective blocks when the disc is produced or formatted.

When defective blocks are found during this check, their addresses are recorded sequentially in the PDL as the defect addresses dfaP1, dfaP2, dfaP3, etc.

In this case, the replacement block for each defective block found is the next block after the found defective block. In other words, the blocks used for recording are shifted according to the defective blocks, and this is a "slipping operation."

The slipping operation is illustrated schematically in Fig. 4A.

One division in Fig. 4A indicates one block, and the total number of divisions indicates the sections included between "Bn - 3" and "Bn + 5" (certain sections in the user area) as physical addresses (PBA). If the block with the physical address Bn is defective, the value of physical address Bn is recorded as a defect address dfaP(x) in the PDL.

In this case, the slipping operation is performed, the block with the next physical address after Bn + 1 being used in place of the block with the physical address Bn. Thus, the blocks

are used with a one-block shift, as indicated by the addresses in parentheses in the second row of Fig. 4A. (Obviously, however, the physical addresses are not actually changed.)

In the PDL, used as defect management data for the slipping operation, a replacement block for a defective block is the block next to the defective block, so that it is not necessary to manage the address of a block in place of a defective block. Consequently, in the PDL, only a few bytes (7 to 8) are used for the address of each defect. The number of defective blocks found during the defect check is recorded as the entry-point number of the PDL.

The SDL is used to manage defective sectors found by the user under operating conditions.

The defect addresses dfaS1, dfaS2, dfaS3, etc., obtained when the defective blocks are found and the addresses rpa1, rpa2, rpa3, etc., of replacement blocks corresponding to the defective blocks are recorded in the SDL. In addition, at the beginning of the SDL, the number of defective blocks recorded and found is recorded as the entry-point number for the SDL.

A form of defect management by means of the SDL is termed "linear replacement," in which the contents of the list are updated each time a defective block is found by the user in the operating state.

In other words, a block of a replacement area is assigned to be the replacement block for the defective block found by the user in the operating state. Thus, as described hereinabove, 14 to 16 bytes of SDL data, including several bytes (7 to 8) as the defect address dfa(x) and a few bytes (7 to 8) as the replacement address rpa(x), are used per defective block found.

Figure 4B is a diagram illustrating the linear replacement operation.

Figure 4B further shows, in the form of physical addresses (PBA), the sections located between "Bn - 3" and "Bn + 5" (certain sections of the user area), and it is assumed that the block having the physical address Bn has just been found to be defective. Accordingly, a block that is to replace the block with the physical address Bn is present as a given block (address Bm + 2" [sic]) in the replacement area. The address Bn of the defective block, constituting the defect address dfa(x), and the address Bm + 2 of the replacement block used, constituting the replacement address rpa(x), are recorded in the SDL.

This is followed in this case by a linear replacement operation in which the block with

the physical address Bm + 2 is used in place of the block with the physical address Bn.

The defect conditions are managed in the defect management areas DMA as described hereinabove. Thus, a recording or reproduction system can execute a recording or reproduction operation based on defect management of the disc by reading the DMA data from the disc D.

(2) Hardware Structure of the Reproduction System

Figure 5 is a block diagram of the hardware components of the reproduction system according to the present invention.

This reproduction system is formed by connecting a disc reproduction apparatus 1 and a host computer 2 via an SCSI or ATAPI interface so that they are able to communicate with each other.

The host computer 2 comprises, for example, a hard disc drive device 31 for hard discs as the internal storage medium, in which an application program or the like is installed. In addition, the reproduction system includes a keyboard 33 constituting a data acquisition device for the host computer 2 and a display unit 32 constituting an output display device.

A DVD-RAM or DVD-ROM, in the form of a disc D, is loaded into the disc reproduction apparatus 1.

The disc D is mounted on a turntable 17 and in reproduction mode is driven rotationally at a constant linear velocity by a spindle motor 16.

The data recorded in the form of embossed pits or phase-change pits on the disc D are read by means of a pick-up 11.

The pick-up 11 has an optical system, which is the most suitable for DVD discs. For example, a laser diode 14 constituting a laser-beam source transmits a laser beam with a central wavelength of 650 or 635 nm. A lens 12 has a numerical aperture NA = 0.6. The lens 12 is supported by a biaxial mechanism 13 to enable it to move in the tracking direction and in the focusing direction.

The data are read from the disc D by means of the pick-up 11. In the pick-up 11, a detector 15 detects the reflected-light data from the disc D and converts them to electrical signals, based on the quantity of received light, before transmitting the electrical signals to a

high-frequency amplifier 19.

The amplifier 19 includes a current-voltage transformation circuit, an amplifier circuit, a parent operational circuit, etc., and it generates the necessary signals from the signals delivered by the detector 15. For example, the amplifier 19 generates a high-frequency signal as reproduced data, a focusing error signal FE for the servocontrol, a tracking error signal, an inwardly offset signal PI in the form of a so-called "sum" signal, etc.

The various signals generated by the amplifier 19 are transmitted to a binary counter 22 and a servoprocessor 26. In other words, the high-frequency reproduced signal output by the amplifier 19 is transmitted to the binary circuit 22, and the focusing error signal FE, the tracking error signal TE and the offset signal PI are transmitted to the servoprocessor 26.

The high-frequency reproduced signal obtained by amplifier 19 is converted to binary values by binary circuit 22, and is thereby converted to an 8-14-modulated positive signal (EFM [eight-to-fourteen modulation]) (8-16-modulated signal). The positive EFM signal is transmitted to a decoder 23. The decoder reproduces the data read from the disc D, performing positive EFM demodulation, decoding by cross-interleaved Reed-Solomon code (CIRC) and CD-ROM decoding, optionally with decoding according to the MPEG standard of the Moving Pictures Experts Group.

The decoded data are transmitted to the host computer 2 via an interface unit 24.

The servoprocessor 26 generates various types of servo control signals, for example focusing, tracking and positioning, and spindle signals for executing servo operations by means of the focusing error signal FE and the tracking error signal TE from the amplifier 19 and a spindle error signal SPE from the decoder 23 or a system controller 21.

In other words, processor 26 generates the focus control signal and the tracking control signal on the basis of the focusing error signal FE and the tracking error signal TE and transmits the generated signals to a biaxial drive circuit 28. This circuit 28 drives the biaxial mechanism 13 by transmitting currents based on the focusing error signal FE and the tracking error signal TE to the focusing coil and the tracking coil of the biaxial mechanism 13. This arrangement forms a tracking servo loop and a focusing servo loop by means of pick-up 11, amplifier 19, processor 26 and drive circuit 28.

Servoprocessor 26 also transmits to the spindle-motor drive circuit 29 the spindle drive

signal generated on the basis of the spindle error signal SPE. This drive circuit 22 [number sic] causes the spindle motor 16 to rotate at a constant linear velocity by applying to the motor 16, for example, a three-phase drive signal based on the spindle drive signal. Processor 26 generates the spindle drive signal based on a spindle acceleration/braking control signal and causes drive circuit 29 to control or stop spindle motor 16.

Processor 26 generates a positioning drive signal that depends, for example, on a positioning error signal obtained from a short-range component of the tracking error signal TE and on an access execution command from the system controller 21, and it transmits the generated signal to a positioning drive circuit 27. This circuit 27 drives a positioning mechanism 18 on the basis of the positioning drive signal. Mechanism 18 moves the entire pick-up 11 radially over the disc. Drive circuit 27 drives the positioning motor mechanism 18 on the basis of the positioning control signal so that the proper sliding movement of the pick-up 11 is performed.

The laser diode 14 of the pick-up 11 is activated by the laser drive circuit 30, which emits a laser beam[4].

The servo processor 26 generates a laser drive signal for the execution of laser emission by the pick-up 11 in reproduction mode according to an instruction from the system controller 21, and transmits the generated signal to the laser drive circuit 30. This circuit 30 causes the laser diode to emit a beam based on the laser drive signal.

The aforesaid servo and decoding operations are controlled by the system controller 21, which includes a microprocessor.

Operations such as starting and terminating reproduction, track access, rapid reproduction and rapid reverse reproduction are realized such that system controller 21 controls the movement of processor 26 or pick-up 11.

A memory 25 is a CPU-built-in memory of the system controller 21 in the form of a microprocessor, and is used to store the data for the various operations necessary for the control of movement or in a work region.

Control of reproduction from the disc D by the system controller 21 is executed in

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[4]TRANSLATOR'S NOTE: Sic, with the drive circuit identified as emitting the beam.

accordance with a reproduction request and a reproduction position designation from the host computer 2.

In other words, the host computer 2 transmits, with a command constituting a reproduction request, an address (in this case, a physical address to be used for defect management, as described above) as reproduction-position and data-length data. Based on these data, controller 21 commands processor 26 to execute rotation by spindle motor 16 and access to the disc D by pick-up 11, so that the requested data file is read. Subsequent control of the reproduction operation is then terminated by transmission of the data file read by pick-up 11 and decoded by decoder 23 from interface unit 24 to host computer 2.

(3) Functional Blocks of the Reproduction System

Figure 6 shows a reproduction operation performed by the system described with reference to Fig. 5, in the form of a functional block diagram.

The host computer 2 has software in the form of a disc drive circuit 6 operating under the control of an operating system (OS) 7 to adapt it to the disc reproduction apparatus 1. The disc drive circuit 6 has a file system function 6a to contain the read file management data from the disc D loaded into apparatus 1, and a drive circuit function 6b to execute the reading of the data from the file requested by operating system 7, out of the file data managed by file system function 6a.

In this embodiment, drive circuit 6 has a defect table function 6c designed to contain the defect management data read from the disc D and to contain a table generated on the basis of the replacement data included in the defect management data, that is, a table designed to contain the defects that have occurred, to facilitate address conversion based on the replacement data. The drive circuit 6 also has an address transformation function designed to use the defect table to execute address conversion based on the replacement data.

The disc reproduction apparatus 1 comprises a disc drive unit 3 composed, for example, of an optical head, a servomechanism, a decoding circuit, etc., to permit actual reproduction of the data from the disc D. The disc drive unit 3 has the same components as apparatus 1 shown in Fig. 5, except for system controller 25 and interface unit 24. The disc drive unit 3 has a controller 4 that corresponds to system controller 25 and interface unit 24 of Fig. 5.

When a read request for a certain data file is generated by operating system 7 in the reproduction system composed of host computer 2 and disc reproduction apparatus 1, disc drive circuit 6 transmits to apparatus 1 a read command (read request) and position data relating to the location at which the read is executed.

In this embodiment, the position data consist of the start address of an area in which a read is executed and a data file length (data length). The start address to be transmitted consists of one or more physical addresses PBA# and a data length LG# obtained by transformation of the logical address LBA and the data length LG based on management of the data file from the disc D [phrase sic] by the host computer 2.

The controller 4 of apparatus 1 receives the read command from the host computer 2 and the address and data length as read-position data, and therefore causes unit 3 to execute a read based on the received read-position data. However, controller 4 treats the received address as a logical address, as in the case of its conventional response to a DVD-ROM. In other words, regardless of whether or not the loaded disc is a DVD-RAM, the controller 4 treats the transmitted data composed of physical addresses PBA# and data length LG# as a logical address and a data length, and thus obtains a physical address at which actual reading from the disc D is executed by means of an offset adding function 4a, which adds an offset to the logical address.

The data reproduction command is executed on the basis of the physical address and the data length LG# obtained.

In other words, in this embodiment, the address transmission [sic] based on the defect management condition that is necessary for a DVD-RAM medium is executed in the drive circuit 6 of host computer 2. A reproduction instruction transmitted to apparatus 1 is emitted with an address transformation appropriate to the defect management performed.

Thus, disc reproduction apparatus 1 merely has to execute the addition of an offset to the address transmitted with the read request, regardless of whether the disc D is a DVD-ROM or a DVD-RAM medium.

The invention is described hereinbelow in this embodiment, as the case in which reproduction apparatus 1 executes the offset addition in the manner described above. However, the reproduction system can also have a structure in which the controller 4 of

apparatus 1 uses a transmitted address as the actual read address for executing the access permitting reproduction.

(4) Initial Process

The initial process for reproduction in the reproduction system will now be described as a specific example with reference to the flow chart of Fig. 7.

This initial process is an operation of the host computer 2 that is executed when the disc D is loaded into the apparatus 1 or when the computer 2 is activated while the disc D is loaded in the apparatus 1.

In step F101, computer 2 initially recognizes the type of disc D loaded into apparatus 1, in other words, whether the disc is a DVD-ROM- or DVD-RAM-type disc. In the case of an SCSI or ATAPI connection as described in this embodiment, computer 2 can determine the type of disc D from the information regarding the type of medium, which is a parameter of a mode detection command.

When the disc D is a DVD-ROM, no special initial processing is necessary, and the initial process therefore ends with step F102.

When the disc D is a DVD-RAM, the host computer 2 proceeds from step F102 to step F103 in order to perform the defect-management-related steps that are part of the initial process.

In step F103, the host computer 2 uses a special command to command the reproduction apparatus 1 to read the defect management areas DMA on the disc D. More precisely, host computer 2 commands apparatus 1 to reproduce the defect management data as the disc definition structure DDS, the primary defect list PDL and the secondary defect list SDL, thereby causing apparatus 1 to transmit the reproduced defect management data to host computer 2. The host computer receives the transmitted defect management data in a memory region that is to be used by device drive circuit 6.

The normal access area on the disc D is in the user area, whereas the defect management areas (DMA) are outside the user area.

Thus, in order for host computer 2 to be able to read the data from a defect management area DMA on the DVD-RAM constituting disc D, the range of logical addresses LBA

associated with the read request must be extended by the size of the defect management areas located before and after the user area. Hence, according to a proposed standard for DVD-RAMs, the range of logical addresses LBA is extended before and after user area by 60h.

After the defect management data have been read from the disc D, in step F104, a necessary memory region is reserved, based on the number of defects recorded in the primary list PDL and the secondary list SDL. In step F105, a defect table for transforming the logical address LBA into a physical address PBA# is generated from the primary defect list PDL and the secondary defect list SDL.

The physical address PBA# is an address that corresponds to a physical replacement position based on the defect management status, and is an address to which an offset for logical-address-to-physical-address transformation has not been added.

Accordingly, apparatus 1 adds the offset to the physical address PBA#, and an actual, physical read position can therefore be represented by the sum.

As described above, a defect table having an offset addition can be generated in step F105. In this case, apparatus 1 must simply execute an address command analogous to that performed when the DVD-ROM is loaded.

Once the defect table has been generated and defect table function 6c of drive circuit 6 has been activated, the initial process ends. Subsequently, when a reproduction operation on disc D, which is a DVD-RAM, is requested, address transformation function 6d uses defect table function 6c to effect address transformation, and drive circuit function 6b uses the transformed address PBA# and the data length LG# to send a read request for disc reproduction apparatus 1.

(5) Reproduction Operation

Figure 8 represents an operation in the case where a read request is generated by the operating system 7 after the end of the initial process.

Once a request to read a necessary data file has been generated by operating system 7, the processing passes from step F201 to step F202. At this time, file management, via function 6a, generates the logical address LBA and the data length LG of the necessary data file.

In this case, address transformation function 6d uses defect table function 6c to transform the logical address LBA and the data length LG into one or more position data elements, i.e., the physical address PBA# and the data length LG#.

Different types of necessary operations are performed for the aforesaid address transformation operation, and the following three are considered: the case in which the data to be read do not include a defective block, the case in which the data file to be read contains a defective block recorded in the primary defect list PDL, and the case in which the data file to be read contains a defective block recorded in the secondary defect list SDL.

In reality there can be various cases, such as the case in which the data file to be read includes plural defective blocks recorded in the primary list PDL, the case in which the file to be read contains plural defective blocks recorded in the secondary list SDL, and the case in which the data file to be read contains both a defective block recorded in the primary list PDL and a defective block recorded in the secondary list SDL. Depending on the type of defective block, position data transformation (address and data length transformation) is executed as described below.

Initially, when it has been determined by reference to the defect management data that the data file sections to be read do not include a defective block, the actual address and data-length transformation is not executed.

For example, when a read request in which the logical address LBA = 16W and the data length LG = 4 is generated, it is requested that the data files of the four blocks having the logical addresses 16W, 16W + 1, 16W + 2 and 16W + 3 be reproduced. However, if it is confirmed from the defect management data (or the defect table) stored in function 6c that there are no defective blocks in the actual recording areas on the disc D corresponding to the four blocks, the address transformation function 6a does not specifically have to execute an address transformation based on the defect condition, and transfers to drive circuit function 6b[5] the values in which logical address LBA = 16W and data length LG = 4 are the values of the physical addresses PBA# = 16 and the data length LG# = 4.

[5]TRANSLATOR'S NOTE: The French actually says "function 6b of the drive circuit," here and throughout the rest of the document. We will stay with the original phraseology, as it appears, for example, in the first paragraph of the specification.

After the end of the aforesaid processing in step F202, function 6b executes the read command in apparatus 1 in step F203. In other words, it transmits a read request command and read position data with the address 16W and the data length 4.

Following the read command transmitted in step F203, the disc reproduction apparatus 1 recognizes the transmitted address (physical address PBA#) as an address to which no offset has been added, i.e., a logical address, and the controller 4 uses the offset adding function 4a to add an offset value to the logical address so as to create an actual physical address PBA. Controller 4 instructs disc drive unit 3 to execute a reproduction operation in the sections represented by the data length LG (= LG#) beginning with the physical address PBA, and transmits the reproduced data files to the host computer 2.

In addition, when it is confirmed by reference to the defect management data that the data file sections to be read in response to the request from the operating system 7 contain a defective block recorded in the primary list PDL, the address transformation for this case, i.e., address transformation by slipping, is executed in step F202.

Address transformation will now be described with reference to Fig. 9.

For example, when a read request in which logical address LBA = 16X - 2 and data length LG = 4 is generated, it is requested that the data files of the four blocks having the addresses 16X - 2, 16X - 1, 16X and 16X + 1 be reproduced, as indicated by the LBA space in Fig. 9.

However, if the record block whose physical address corresponds to the block with the logical address 16X (corresponding to the physical address 16Y in the PBA space) is recorded in the primary defect list PDL, the read position related to the read request having the logical address LBA = 16X - 2 and the data length LG = 4 indicates that a request is being made to reproduce the data files of the four blocks 16Y - 2, 16Y - 1, 16Y + 1 and 16Y + 2, as indicated in Fig. 9, since the defective blocks in which a slip is performed must be recorded in the primary list PDL.

In other words, address transformation function 6d uses defect table function 6c to transform the read position data having the logical address LBA = 16X - 2 and the data length LG = 4 into position data representing the physical addresses 16Y - 2, 16Y - 1, 16Y + 1 and 16Y + 2. More precisely, two groups of sections are formed, before and after the

physical address 16Y. Thus, the two groups of sections are transformed into two position data elements: data comprising PBA#1 = 16Y - 2 and a data length LG#1 = 2, and data having the physical address PBA#2 = 16Y + 1 and the data length LG#2 = 2, transferred to drive circuit function 6b.

After the end of the aforesaid address transformation of step F202, function 6b executes the read command of apparatus 1 in step F203, thus transmitting a read request command and the following values as read position data: (address = 16Y - 2 and length = 2) and (address = 16Y + 1 and length = 2).

Following the read command executed in step F203, the disc reproduction apparatus 1 recognizes the transmitted addresses (physical addresses PBA#1 and PBA#2) as addresses to which no offset has been added, i.e., as logical addresses. The controller 4 uses the offset adding function 4a to add the offset values to the logical address, creating the real physical addresses PBA1 and PBA2. Controller 4 instructs disc drive unit 3 to execute a series of operations including a reproduction operation on two-block sections represented by the length LG (LG#1 = 2) starting at the physical address PBA1 and a reproduction operation on two-block sections represented by the length LG (LG#2 = 2) starting at the physical address PBA2, with the result that reproduction is performed and the reproduced data files are transmitted to the host computer 2. This operation terminates the reproduction of the data file in the sections requested by operating system 7.

In addition, when the sections of the data file for which operating system 7 has generated a read request include a defective block recorded in the secondary list SDL with reference to the defect management data, address transformation in this case is performed in step F202, and in this case the address transformation is performed by linear replacement.

This address transformation will now be described with reference to Fig. 10.

For example, when a read request having the logical address LBA = 16X - 2 and the length LG = 4 is generated, a request is made for reproduction of the data files of the four blocks having the logical addresses 16X - 2, 16X - 1, 16X and 16X + 1, as indicated by the LBA space in Fig. 10.

However, if the record block having the physical address corresponding to the logical address 16X (corresponding to the physical address 16Y in the PBA space shown in Fig. 10)

is recorded in the secondary defect list SDL, the read position having the logical address LBA = 16X - 2 and the length LG = 4 for this read request indicates, as shown in Fig. 10, that the data files of four blocks are to be reproduced in the form of two blocks of the data area (addresses 16Y - 2 and 16Y - 1), one block of the replacement area (physical address Z), and one block of the data area (address 16Y + 1), since the addresses of the defective block and the replacement block to be processed by linear replacement are recorded in the secondary defect list SDL.

Thus, address transformation function 6d uses defect table function 6c to transform the read-position data having the logical address LBA = 16X - 2 and the length LG = 4 into position data representing the physical addresses 16Y - 2, 16Y - 1, Z and 16Y + 1. More precisely, since the portion to be read is separated into three sections, address transformation function 6d transforms the read position datum into three position data elements: position data of physical address PBA#1 = 16Y - 2 and length LG#1 = 2, position data of physical address PBA#2 = 2 and length LG#2 = 1, and position data of physical address PBA#3 = 16Y + 1 and length LG#3 = 1. The transformed data elements are transferred to drive circuit function 6b.

After the aforesaid transformation has been executed in step F202, drive circuit function 6b executes the read command of reproduction apparatus 1, thus transmitting a read request command, and the following values are used as read-position data: (address = 16Y - 2, data length LG = 2), address = Z, data length LG = 1), (address = 16Y + 1, data length LG = 1).

Following the read command executed in step F203, the disc reproduction apparatus 1 recognizes the transmitted addresses, which are the physical addresses PBA#1, PBA#2 and PBA#3, as addresses to which no offset has been added, i.e., as logical addresses. Controller 4 uses offset adding function 4a to add offsets to the logical addresses and to form actual physical addresses PBA1, PBA2 and PBA3. Controller 4 instructs disc drive unit 3 to execute a series of operations including a reproduction operation on two-block sections represented by the length LG (LG#1 = 2) starting at the physical address PBA1, and a reproduction operation on a one-block section represented by the length LG (LG#2 = 1) starting at the physical address PBA2, and a reproduction operation in one section represented by the length LG (LG#3 = 1), reproduction thus being performed and the reproduced data files being

transmitted to the host computer 2. The reproduction of the data file in the sections requested by operating system 7 is thereby terminated.

The foregoing processing enables the disc reproduction apparatus 1 to function in a manner such that when a read request is generated by the host computer 2, apparatus 1 simply adds offsets to the transmitted addresses and executes the reproduction operation based on the sums.

In other words, the disc reproduction apparatus 1 has the function of executing a reproduction operation in the defect management areas DMAs in accordance with a particular command from the host computer 2 before transmission of the reproduced data to the computer 2; in other words, reproduction apparatus 1 has a small computer program designed to respond to a specific command, enabling apparatus 1 to manage a DVD-RAM medium as in the ordinary reproduction of the almost conventional functions [sic] adapted to DVD-ROMs only, particularly without the use of very large microinstructions for defect management.

In addition, the device drive circuit 6 built into the host computer 2 performs defect management of high efficiency since memory regions can be reserved based on the number of defects in the host computer 2. In other words, when apparatus 1 performs defect management, it must have a storage capacity that allows for the maximum number of defects that can be managed by the defect management areas DMA based on the DVD-RAM medium, and that is set to a value that is much higher than the number of defects ordinarily generated. When the host computer 2 performs defect management, however, the storage region can be reserved on the basis of the number of defects actually read from the medium and recorded. For example, even if one hundred defective blocks are recorded in the primary defect list PDL and one hundred defective blocks are recorded in the secondary defect list SDL, a storage capacity of about one kilobyte will be sufficient, and there is no waste due to the use of a memory [sic] in the host computer 2 (i.e., use of the memory of the system as a whole).

It is understood that various modifications to the systems, apparatuses and processes that have just been described, solely as nonrestrictive examples, can be made by one skilled in the art without departing from the scope of the invention.

CLAIMS

1. A reproduction system comprising a host apparatus (2) and a reproduction apparatus (1) designed to execute a reproduction operation with respect to a predetermined recording medium, the two apparatuses being connected so that they mutually communicate, characterized in that:

said reproduction apparatus (1) comprises:

a reproduction device designed to read data from the predetermined recording medium, and

a reproduction control device designed to cause said reproduction device to read defect management data recorded on the recording medium in accordance with a command from said host apparatus (2) before transmission of the reproduced defect management data to said host apparatus (2), and to cause said reproduction device to execute a reproduction operation in accordance with both a read request and read-position data from said host apparatus (2) before transmission of the reproduced data to said host apparatus (2), and

said host apparatus (2) comprises:

a defect management device designed to contain the defect management data transmitted by said reproduction apparatus (1), and

a reproduction request device designed to command said reproduction apparatus (1) to read the defect management data present on the predetermined recording medium loaded into said reproduction apparatus (1), and to transform the generated logical read-position data into read-position data adapted to the defect management status of the predetermined recording medium by reference to defect management data stored in said defect management device before transmission of the transformed read-position data with a read request when said host apparatus (2) causes said reproduction apparatus (1) to execute the reading of data.

2. The reproduction system as recited in claim 1, characterized in that said reproduction control device determines whether or not the [sic] defect management data are recorded on the predetermined recording medium, and on determining that the defect management data are

recorded, said reproduction control device transmits the defect management data to said host apparatus (2) in accordance with a command from said reproduction request device.

3. The reproduction system as recited in claim 1, characterized in that said reproduction control device determines whether the predetermined recording medium is of a type that is rewritable or is used solely for reading, and on determining that the predetermined recording medium is of a rewritable type, said reproduction control device transmits the defect management data to said host apparatus (2) following a command from said reproduction request device.

4. A reproduction apparatus designed to execute a reproduction operation from a predetermined recording medium, said reproduction apparatus (1) being connected to a host apparatus (2) so that the apparatuses communicate, said reproduction apparatus (1) being characterized in that it comprises:

a reproduction device designed to execute a data reading operation with respect to the predetermined recording medium, and

a reproduction control device designed to cause said reproduction device to execute the reading of defect management data present on the predetermined recording medium following a command from said host apparatus (2) before transmission of the reproduced defect management data to said host apparatus (2), and causing said reproduction device to execute a reproduction operation in accordance with a read request and read-position data from said host apparatus (2) before transmission of the reproduced data to said host apparatus (2).

5. A reproduction apparatus as recited in claim 4, characterized in that said reproduction control device determines whether or not defect management data are recorded on the predetermined recording medium, and on determining that defect management data are recorded, said reproduction control device transmits the defect management data to said host apparatus (2) in accordance with the read request from said host apparatus (2).

FIGURES:

FIG. 1. PRIOR ART

FIG. 2.

KEY: 1. INNER
2. OUTER
3. LEAD-IN
4. USER AREA
5. LEAD-OUT
6. CNT = CONTROL
7. DMA = DEFECT MANAGEMENT AREA
8. DATA AREA
9. REPLACEMENT AREA
10. DOMAINE = DOMAIN

FIG. 3.

KEY: 1. DDS = DISC DEFINITION STRUCTURE
2. PDL = PRIMARY DEFECT LIST
3. SDL = SECONDARY DE[illegible]
4. ENTRY-POINT NO[illegible]
5. ENTRY-POI[illegible] OF SDL

FIG. 4.

KEY: 1. PDL RECORD: Bn
2. REPLACEMENT AREA
3. SLD [sic]: RECORD: Bn, Bm + 2

FIG. 5.

KEY: 1. SCSI = SMALL COMPUTER SYSTEMS INTERFACE
ATAPI = AT ATTACHMENT PACKET INTERFACE
2. EFM = EIGHT-TO-FOURTEEN-MODULATED
3. RF = RADIO-FREQUENCY
4. PI = PULL-IN
FE = FOCUSING ERROR
TE = TRACKING ERROR
SPE = SPINDLE ERROR

FIG. 6.

KEY: 1. SCSI = SMALL COMPUTER SYSTEMS INTERFACE
ATAPI = AT ATTACHMENT PACKET INTERFACE
2. PBA = PHYSICAL BLOCK ADDRESS
3. LBA = LOGICAL BLOCK ADDRESS
3. LG = DATA LENGTH

FIG. 7.

KEY: 1. START
2. RECOGNIZES TYPE OF MEDIUM LOADED INTO REPRODUCTION APPARATUS
3. MEDIUM WRITABLE?
4. NO
5. YES
6. READS DEFECT MANAGEMENT AREA (DISC DEFINITION STRUCTURE, PRIMARY DEFECT LIST, SECONDARY DEFECT LIST)
7. RESERVES NECESSARY STORAGE BASED ON NUMBERS OF DEFECTS IN PRIMARY, SECONDARY DEFECT LISTS
8. GENERATES DEFECT TABLE

FIG. 8.

KEY: 1. READ COMMAND FROM OPERATING SYSTEM?
2. NO
3. YES
4. USES DEFECT TABLE TO TRANSFORM (LBA/LG) INTO ONE OR MORE READ COMMANDS (PBA#, LG#)
5. EXECUTES ONE OR MORE READ COMMANDS (PBA#, LG#) FOR REPRODUCTION APPARATUS

FIG. 9.

KEY: 1. READ REQUEST
2. LBA SPACE
3. PBA SPACE
4. EXECUTION OF A READ
5. READ COMMAND FROM OPERATING SYSTEM
6. TRANSFORMED# READ COMMAND

FIG. 10.

Key same as for Fig. 9, with the addition:

7. REPLACEMENT AREA